NASA CONTRACTOR
REPORT

NASA CR-61343

RELIABILITY TESTS CONDUCTED ON FIVE (5) CRYO-FORMED SPHERES

Ogden Technology Laboratories, Inc.
Beaumont Facility
Beaumont, California

August 1969

Test Report

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

NOTICE

Because of a waiver initiated and signed in compliance with NASA Policy Directive (NPD) 2220.4, para. 5-b, the International System of Units of measurement has not been used in this document.

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Ogden Technology Laboratories, Inc.
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NAS 8-30029

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16. Abstract

A test program is carried out to verify the reliability of the manufacturing technology used in the production of the cryo-formed spheres, and to determine their suitability for use as replacements for the titanium Helium storage bottles currently installed in the liquid Hydrogen tanks in the S IV-B Stage of the Saturn IB vehicle. Each test is summarized and the results given at the end of the test write-up.

NOTE: The test data that was generated in these tests is an addendum to this report and is available as Appendix 1, upon request, from the following address:

George C. Marshall Space Flight Center
Marshall Space Flight Center, Ala. 35812
Attn: Floyd Bulette, A&TS-TU

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ADMINISTRATIVE DATA

PURPOSE OF TEST:	The objective of this test program was to verify the reliability of the manufacturing technology used in the production of the cryo-formed spheres, and to ascertain their suitability for utilization as replacements for the titanium Helium storage bottles currently installed in the liquid Hydrogen tanks in the S IV B Stage of the Saturn IB Vehicle.
MANUFACTURER:	ARDE, INC. Paramus, New Jersey
MANUFACTURER'S DESIGNATION:	Saturn S-IVB Helium Storage Vessel Part No. D3590.
GOVERNMENT CONTRACT NUMBER:	NAS 8-30029. DO-A2 Priority
SPECIFICATION REFERENCES:	1. George C. Marshall Space Flight Center, Purchase Order NAS 8-30029. 2. R.F.Q. 1-8-30-25733 3. Ogden Technology Laboratories, Inc. Test Procedure No.B-20415, Rev. A. 4. Ogden Technology Laboratories, Inc. Safety and Health Procedure No. B-20415-S.
SECURITY CLASSIFICATION:	None
QUANTITY OF ITEMS TESTED:	Five (5). Serial Numbers: 4, 8, 9, 10, and 11.
DATE TESTS COMPLETED:	September 17, 1969.
TESTS CONDUCTED BY:	Ogden Technology Laboratories, Inc. Jack Rabbit Trail P.O. Box 181 Beaumont, California 92223
TESTS CONDUCTED AT:	Ogden Technology Laboratories, Inc. Remote Test Facility Beaumont, California; and, Magnaflux Materials Testing Laboratory 6800 East Washington Boulevard Los Angeles, California.

ADMINISTRATIVE DATA - Continued

DISPOSITION OF SPECIMENS: Specimens Serial Numbers 4, 6, 10, and 11, and the recovered fragments of Specimens' Numbers 8 and 9 are to be returned to Marshall Space Flight Center.

1.0 SPECIFICATION REFERENCES AND REQUIREMENTS

In accordance with George C. Marshall's Purchase Order No. NAS 8-30029, authority was issued to Ogden Technology Laboratories, Inc., to conduct reliability tests on five (5) Cryo-formed Spheres (ARDE Part No. D-3590), Serial Numbers 4, 8, 9, 10, and 11. Serial Number 6 was utilized for set up and check out purposes.

Specific tests were conducted in accordance with Ogden Technology Laboratories Test Procedure No.B-20415, Rev. A, dated 24 July 1968, and as listed in Table I below.

TABLE I

TEST	Paragraph	Serial Numbers 4	8	9	10	11
Proof Ambient	2.1	x	x	x	x	x
Proof Cold	2.2	x	x	x	x	x
Leak Ambient	2.3	x	x	x	x	x
Thermal Shock	2.4	x	x	x	x	x
Service Life	2.5	x	x	x	x	
Stress Coat	2.6	x				
Vibration	2.7		x	x		
Burst	2.8		x	x		

All raw data generated during the listed tests has been reduced and is summarized on data sheets that have been separated from this report. All raw data and the original oscillograph recordings have been retained at Ogden Technology Laboratories, Inc., Beaumont Division.

2.0 GENERAL INFORMATION

2.1 Test Conditions

Unless otherwise stated in the body of this report, all tests were conducted at an ambient temperature of +77°F ±20°F, a relative humidity of 95% or less and a barometric pressure of 29 ±2 inches of mercury.

2.2 Test Condition Tolerances

1)	Sinusoidal Vibration Amplitude	±10%
2)	Sinusoidal Vibration Frequency	± 2%
3)	Random Vibration Density 20-1000 cps	± 2db
	Random Vibration Density 1000-2000 cps	± 4db
4)	Pressure	± 5%
5)	Time	± 5%
6)	Leakage Rate	±10%
7)	Barometric Pressure	± 2%

2.3 Test Equipment

All test equipment used in the performance of the tests described in this report is calibrated at intervals sufficient to assure continued accuracy and repeatability of recorded measurements. Calibration records are maintained on file for study by authorized personnel upon request.

Calibration standards are traceable to the National Bureau of Standards and certifications are retained on file and are available upon request to authorized personnel.

All vibration systems are calibrated immediately before each successive use in addition to the regularly scheduled test calibrations.

2.4 Test Fixture

The test fixture used for the performance of the vibration tests was designed by Ogden Technology Laboratories, Inc., and has a designated Part Number 9100 NAS 8-30029.

2.5 Test Media

2.5.1 Helium

Gaseous Helium utilized throughout the program, conformed to U.S. Bureau of Mines, Helium Grade A. Dew Point was always less than -76°F.

2.5.2 Liquid Hydrogen

The Liquid Hydrogen utilized throughout this program conformed to MIL-P-27201.

3.0 DISCUSSION OF TESTS

3.1 Proof Test - Ambient

3.1.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A, dated July 24, 1968, Paragraph 2.1.

The specimen shall demonstrate its structural integrity when subjected to a gaseous Helium pressure of 3,500 psig for two (2) minutes at a temperature of 70 ±10°F. This integrity shall be measured by: a) Comparing measurements of the specimen's diameter, taken at six (6) locations, before and after pressurization, b) Visual observation of pressure decay during the two (2) minute pressurization period.

2.1.2 Test Procedure

Prior to installing each of the five (5) test specimens in a holding fixture, six (6) points were picked at random, and identified, to serve as locations for measuring and recording the diameter of each sphere, when required, throughout the entire test program. A high pressure gaseous Helium source was connected to the inlet of the specimen, thermocouples were installed and a shroud, for temperature conditioning, was placed over the specimen. While maintaining the specimen at 70 ±10°F, gaseous Helium was slowly introduced into the specimen until a pressure of 3,500 psig was reached and maintained for two (2) minutes. The Helium pressure was then vented from the specimen, into the recovery system, at a flow rate commensurate with maintaining the specimen temperature at 70 ±10 °F. With the specimen at ambient pressure, measurements of the specimen's diameter, at the designated six (6) locations, were taken and recorded. The foregoing procedure was then repeated for each of the remaining four (4) specimens.

3.1.3 Test Results

The temperature of specimens Serial Numbers four (4) and eleven (11) exceeded the specified 70 ±10°F. during pressurization. The highest recorded temperature, with respect to both specimens, was 90°F for a duration of two (2) minutes. Test Deviation Reports No.s 1 and 2 contain the relevant data and are to be found in Appendix 1, Section I, of this report. Despite the momentary out of specification tolerances, no permanent deformation or change in diameter was noted. Measurement and comparison of the diameter's of Serial Numbers 8, 9, and 10, pre- and post proof test, did not reveal any significant change.

3.0 DISCUSSION OF TESTS - continued

3.2 Proof Test (Cold)

3.2.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A, dated July 24, 1968, Paragraph 2.2.

The specimen shall demonstrate its structural integrity when subjected to a gaseous Helium pressure of 5,340 psig, maintained for two (2) minutes, while submerged in Liquid Hydrogen at -412 ±12°F. This integrity shall be determined by: a) Comparison of the specimen's diameter measurements pre- and post proof test; b) Visual examination on completion of test.

3.2.2 Test Procedure

Measurements of the specimens diameter, at the six (6) locations, were taken and recorded prior to installation in the cryostat. The specimen was suspended in the cryostat and thermocouples installed to record specimen skin temperature and indicate the liquid level in the cryostat. The specimen inlet was then connected to a high pressure gaseous Helium source. Prior to the admission of liquid Hydrogen to the cryostat, the specimen was purged five (5) times with gaseous Helium to expel all air and other contaminants. On completion of the final purge, a positive pressure of fifty (50) psig was allowed to remain in the specimen. Liquid Hydrogen was slowly admitted to the cryostat until three (3) temperature readings, taken fifteen (15) minutes apart, indicated stabilization at -412 ±12°F, and the specimen was then considered submerged in liquid Hydrogen. Gaseous Helium was slowly admitted to the specimen until a pressure of 5,340 psig was reached. The liquid Hydrogen supply was adjusted, as necessary during pressurization, to maintain the specimen at -412 ±12°F. After the pressure had been maintained for two (2) minutes, the Helium in the specimen was vented to the recovery system, the liquid Hydrogen supply to the cryostat was shut off and the specimen allowed to return to ambient temperature and pressure. The foregoing procedure was repeated for the remaining four (4) specimens. When the specimens had returned to ambient temperature and pressure, the six (6) measurements of each specimen's diameter were taken and recorded.

3.2.3 Test Results

No structural deformation or damage was visually apparent at the conclusion of the proof test at -412 ±12°F. Measurements of the specimen diameters, pre- and post test, were compared and no significant changes were evident.

3.0 DISCUSSION OF TESTS - continued

3.3 Leak Test (Ambient)

3.3.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A., dated July 24, 1968, Paragraph 2.3.

The specimen shall be subjected to a gaseous Helium pressure of 2,100 psig for two (2) minutes at a temperature of 70 ±10°F. During the two (2) minutes the pressure gauge shall be monitored for evidence of leakage.

3.3.2 Test Procedure

Prior to installing the first specimen (Serial No. 4), the gaseous Helium system was "capped off" and leak checked at 3,000 psig. The specimen was then installed in the holding fixture and connected to a high pressure gaseous Helium source. While maintaining the specimen at 70 ±10°F, the pressure of the specimen was raised to 2,100 psig. The Helium inlet valve was closed off and the pressure monitored for two (2) minutes for evidence of loss in pressure. On completion of the two (2) minutes, the Helium was vented from the specimen to the recovery system. The foregoing was then repeated for the remaining four (4) specimens.

3.3.3 Test Results

Constant monitoring of the pressure gauge, during the two (2) minute period, did not disclose any leakage with respect to specimens Serial Numbers 4, 8, 9, 10 and 11.

3.0 DISCUSSION OF TESTS - continued

3.4 Thermal Shock Test

3.4.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A, dated July 4, 1968, Paragraph 2.4.

The specimen shall demonstrate its structural integrity when subjected to a temperature shock from +70°F to -423°F, with the internal pressure being raised from 0 - 500 psig. The required temperature and pressure parameters are to be attained in ninety (90) seconds. This integrity shall be measured by: a) Measurement and comparison of the specimen diameters, pre- and post thermal shock; b) Visual examination for evidence of physical damage.

3.4.2 Test Procedure

The dummy specimen, Serial Number Six (6), was installed in the temperature conditioning shroud suspended above the cryostat, as depicted in Figure I of this report. The specimen inlet was connected to a gaseous Helium source, and the skin temperature of the specimen stabilized at 70 ±10°F. The cryostat was then filled with liquid Hydrogen until the thermocouple indicated that the liquid level was sufficient to immerse the specimen (approximately two-thirds (2/3) full). The cover (a ten (10) mil thick polyethylene sheet) was then placed on the cryostat. The Helium supply to the regulator was opened and the specimen slowly lowered into the cryostat, the weight of the specimen breaking the cryostat "cover". The specimen was then pressurized with gaseous Helium, within ninety (90) seconds of it piercing the cryostat cover, to a pressure of 500 psig. The specimen was then withdrawn from the cryostat into the temperature conditioning box and the Helium pressure vented to the recovery system. Satisfied that the internal pressure of the specimen could be raised to 500 psig within ninety (90) seconds of it piercing the cryostat "cover", the foregoing procedure was repeated for specimens Serial Numbers 4, 8, 9,10 and 11. Prior to, and on completion of Thermal Shock, the specimens diameters, at the six (6) locations, were measured and recorded.

3.4.3 Test Results

No deformation was visually evident and comparison of the specimens diameters, pre- and post thermal shock, did not indicate any significant change. Specimen Serial Number eight (8) was subjected to a re-test, Notice of Test Deviation Number 3, dated 28th March 1969, refers. The re-test was conducted as a direct result of an erronerous liquid level reading in the cryostat.

3.0 DISCUSSION OF TESTS - continued

3.5 Service Life

3.5.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A, dated July 24, 1968, Paragraph 2.5.

The specimen shall demonstrate structural integrity when subjected to pressure cycling from 500 psig to 3,700 psig to 500 psig, for a total of 500 cycles, while immersed in liquid Hydrogen at a temperature of -412 ±12°F. The gaseous Helium shall be at ambient temperature, and the pressure cycle shall be completed in less than six (6) minutes. The structural integrity shall be measured by: a) comparison of specimen diameters pre- and post 500 cycles; b) visual inspection; and, c) a leak test, at ambient, after completion of 500 cycles.

3.5.2 Test Procedure

The dummy specimen, Serial Number six (6), was installed in the test loop as shown in Figure II of this report. The test system was "closed loop", and incorporated high and low pressure Helium recovery systems. All valves and controls were automated, and the entire test run remotely. Continuous observation of the test pad was made on a closed circuit television system. Utilizing the dummy specimen, test runs were made to find optimum settings for flow control valves with respect to gaseous Helium and liquid Hydrogen. Satisfied that all test parameters could be met in the specified cycle time of less than six (6) minutes, the dummy specimen was removed from the test system.

Prior to installing specimen Serial Number four (4) in the cryostat, the six (6) diameter measurements were taken and recorded. The specimen was then installed in the cryostat and the inlet connected to a high pressure gaseous Helium source. Thermocouples were bonded to the skin of the specimen and the cryostat cover bolted in place. Prior to the admission of liquid Hydrogen into the cryostat, the specimen was purged five (5) times with gaseous Helium, at ambient temperature, to expel all air and other contaminants. The specimen was then pressurized to 500 psig with gaseous Helium, and liquid Hydrogen was admitted to the cryostat. The flow of liquid Hydrogen was adjusted until three (3) temperature readings of the specimen skin, taken five (5) minutes apart, indicated -412 ±12°F. Concurrently, the Helium pressure was regulated to maintain the specimen pressure at 500 psig. The specimen was then subjected to the following cycle for a total of 500 cycles:

a) Increase pressure from 500 to 3700 psig in less than three (3) minutes.
b) Vent pressure from 3700 to 500 psig, in less than three (3) minutes.
c) Allow temperature to return to -412 ±12°F, then start a new cycle.

3.0 DISCUSSION OF TESTS - continued

3.5 Service Life - continued

3.5.2. (cont'd) After completion of the 500th cycle, the specimen was vented to the atmosphere, returned to ambient temperature, and removed from the cryostat. The specimen was then subjected to a visual examination, measurement of the six (6) diameters, and a leak test, at 2100 psig. The foregoing procedure was then followed for specimens, Serial Numbers 8, 9, and 10.

3.5.3 Test Results

Following the life cycle test, a visual inspection of each specimen revealed no apparent permanent deformation. Comparison of the measurements of the specimen diameters pre- and post life cycle test, did not indicate any significant change. None of the specimens exhibited any leaks during the leakage test performed post 500 cycles as described in Paragraph 3.3.of this report. Specimen, Serial Number 11, was installed in the test loop, but, on instructions from Mr. C. Irvine (M.S.F.C.), was not subjected to the life cycle test.

3.0 DISCUSSION OF TESTS - continued

3.6 Stress Coat Test

3.6.1 Requirement

Reference: Ogden Technology Laboratories, Inc. Test Procedure No. B-20415, Rev. A, dated July 24, 1968, Paragraph 2.6.

The specimen shall be subjected to examination for stress modes by the application of stress coat to the external surface. The specimen shall be filled with distilled water, the internal pressure shall be raised to 500, 750, and 1,000 psig, and the stress patterns photographed. Final qualitative evaluation of the stress maps will be accomplished by N.A.S.A. This test was performed by Magnaflux Corporation.

3.6.2 Test Procedure

Specimen Serial Number four (4) was coated with an aluminum undercoat, ST-840, and allowed to air dry for thirty (30) minutes before applying the stress coat. Stress coat coating Number ST-70 was used in place of ST-1204. Permission to deviate was given in TWX message Number R2617502, dated June 1969. The reason for the change was that ST-70 was a newer formulation requiring less cure time, and humidity did not affect the sensitivity. The threshold strain of this coating, at a temperature of 77°F,was approximately 750 - 800 micro-inches per inch. An additional pressure increment, of 200 psig, was added in order to determine the locations of highest stress before these areas were masked by the more general crack patterns at the higher pressure levels.

3.6.3 Test Results

The results and photographs of the stress modes are contained in Magnaflux Corporation's Report Number 26776-8-1.

3.0 DISCUSSION OF TESTS - continued

3.7 Vibration Test

3.7.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B.20415, Rev. A, dated July 24, 1968, paragraph 2.7.

The specimen shall demonstrate its structural integrity when subjected to sinusodial and random vibration, in three (3) mutually perpendicular axes, at the levels shown in Tables II and III, below. Throughout all vibration testing, orientation of the test specimen and the tank wall section shall be maintained to simulate that in the vehicle configuration. While undergoing vibration, the specimen shall be pressurized with gaseous Helium at 3,200 ±160 psig and the specimen temperature shall be maintained at -412 ±12°F. The specimens' integrity shall be measured by: a) visual inspection on completion of random vibration in each axis; b) a leakage test at 2100 psig and 70 ±10°F.

3.7.2 Test Procedure

Utilizing the dummy specimen, an ambient temperature and pressure fixture analysis was performed in each axis at full sinusoidal and random vibration levels, as shown in Tables II and III below.

TABLE II

SINUSOIDAL VIBRATION LEVELS

Frequency (Hz)	Level
5 - 28	0.085 inches DA
28 - 125	3.5 g Peak
125 - 190	0.0043 inches DA
190 - 2000	8.0 g Peak

TABLE III

RANDOM VIBRATION LEVELS

Frequency (Hz)	Level
20 - 40	0.014 g^2/Hz
40 - 100	+6db/octave, Rise
100 - 700	0.079 g^2/Hz
700 - 2000	-6db/octave, Roll-off

3.0 DISCUSSION OF TESTS - continued

3.7 Vibration Test - continued

3.7.2 (cont'd) Specimen Serial Number eight (8) was mounted in the vibration fixture (Figure II), and two (2) thermocouples were installed, one (1) on the "ear", and one (1) on the "neck" of the specimen. The Marman Clamp was torqued to a value of 65 ±5 in/lbs, and the "tie down" straps were torqued until a tension of 225 +25 lbs was recorded. The specimen-fixture assembly was connected to a high pressure gaseous Helium source by means of a flexible line. The liquid Hydrogen supply and vent systems were connected to the fixture by means of flexible lines. Control valves for the gaseous Helium and liquid Hydrogen supplies were automated, and the entire test was run on a remote shaker with continuous observation by a closed circuit television system. Prior to the admission of liquid Hydrogen to the fixture, the specimen was purged five (5) times with gaseous Helium to expel all air and other contaminants.

While maintaining a positive pressure in the specimen, liquid Hydrogen was slowly admitted to the fixture until the specimen temperature stabilized at -412 ±12°F. Concurrently, the specimen pressure was raised to 3,200 ±160 psig. Stabilization was assumed when two (2) successive temperature readings, taken five (5) minutes apart, measured -412 ±12°F.

While maintaining the temperature and pressure parameters, the specimen was subjected to sinusoidal vibration at the levels shown in Table II. The sweep rate from 5-2000-5 Hz was one (1) octave per minute, and a tracking filter was used over the 5-200 Hz portion of the sweep. The temperature was continuously recorded, and all accelerometer outputs were recorded on an oscillograph. Still maintaining the temperature and pressure conditions, the cold fixture and specimen were equalized -6db down from the random vibration levels shown in Table III. Verification of the equalization was accomplished by cutting a short tape loop and playing it back on to an X-Y Recorder to produce a power spectral density (P.S.D.) plot. Satisfied with the equalization, the random excitation was increased until full level was reached. The specimen was then subjected to a total of twelve (12) minutes random vibration at the levels shown in Table III. During the twelve (12) minute time period, a power spectral density (P.S.D.) plot was made. The specimen was then allowed to return to ambient temperature, the Helium pressure was bled back into the recovery system, and the specimen was removed from the fixture.

3.0 DISCUSSION OF TESTS - continued

3.7 Vibration Test - continued

3.7.2 (cont'd) Specimen Serial Number nine (9) was installed in the vibration fixture and the foregoing procedure repeated. On completion of testing both specimens in this axis, a leak check was performed at 2100 psig. The fixture was then reoriented for the next axis of vibration, maintaining at all times the attitude of the specimen to the tank wall section, relative to the earth's gravity.

3.7.3 Test Results

While undergoing sinusoidal vibration in the X-Axis, specimen Serial Number eight (8) warmed from -400°F to -208°F. Visual inspection on completion of the sinusoidal vibration revealed that the foam insulation on the Plenum had vibrated off. Prior to running random vibration, the Plenum was insulated with a fiberglas wool thermal wrap. Visual inspection at ambient pressure and temperature, post sinusoidal and random vibration on Serial Number eight (8), revealed that three (3) out of the four (4) tie down lugs on the skin section panel (supplied by N.A.S.A.) had torn away. Mr. C. Irvine (M.S.F.C.) was informed by TWX message Number 69-173, dated 7-14-69, and testing was put on a hold status until a reply giving a disposition was received. The reply was contained in TWX message Number R-181240Z, and authorized Ogden Technology Laboratories to effect weld repairs to the tie down clevis, P/N-1A98661. The weld repairs were completed, and no further trouble was experienced with the tie down clevis for the remainder of the vibration test program.

The vibration levels, both sinusoidal and random, were accomplished in all three (3) axis with the exception of random equalization in the Z-Axes.

The test fixture orientation in the Z-Axis, was such that the M.S.F.C. supplied skin panel was perpendicular to the vibration excitor head (the direction of applied vibration). This orientation of the skin section with the Helium Sphere mounted to it was the most severe. Transmissibility of the input levels, the fixture, and skin section to the sphere, could not be attained due to the flexibility of the skin panel. This flexibility of the skin panel (or resonant bandwidth) from approximately 100 Hz to 400 Hz would not allow equalization with in the capabilities of the Ling ASDE-80 automatic Equalizer/Analyzer. The PSD equalization plots 1, 2 and 3 for the Z-Axis illustrate the problem encountered and difficulty of equalizing a flexible member with the test specimen mounted. Relocation of the control accelerometer to a more rigid member would have aided in equalization, but would not have been located at the point of attachment of the sphere as required by M.S.F.C. specification.

3.0 DISCUSSION OF TESTS - continued

3.8 Burst Test

3.8.1 Requirement

Reference: Ogden Technology Laboratories Test Procedure No. B-20415, Rev. A, dated July 24, 1968, Paragraph 2.8.

The specimen shall be placed in an expendable cryostat. To minimize the explosive force (by reducing the gas volume), the specimen shall be filled with Polyethylene beads approximately 1/4 inch in diameter. The specimen shall be submerged in liquid Hydrogen, and the internal pressure shall be raised, using pre-chilled Helium gas (-412 ±12°F), until burst occurs or 10,000 psig is reached. There shall be dwell intervals of three (3) minutes duration at the following pressures: 3,700 psig, 5,340 psig, and 7,100 psig.

3.8.2 Test Procedure

The specimen was filled with polyethylene pellets and placed in an expendable (foam) cryostat, which, in turn, was "buried" in the ground. A high pressure gaseous Helium source was connected to the specimen inlet, and liquid Hydrogen supply lines and vent lines were connected to the cryostat. Thermocouples were bonded to the specimen and connected to a Barber Colman Continuous Strip Chart Recorder. Prior to the admission of any liquid Hydrogen to the heat exchanger (for pre-chilling the gaseous Helium) or the cryostat, the specimen was purged a minimum of five (5) times to expel all air and other contaminants.

The cryostat was then filled with liquid Hydrogen while concurrently introducing pre-chilled gaseous helium into the specimen. The internal pressure of the specimen was then raised to, and held for three (3) minutes at, each of the following pressures: 3,700 psig, 5,400 psig, and 7,100 psig. The rate of increasing the pressure was conducive to maintaining the Helium temperature at -412 ±12°F, but it did not exceed a pressurization rate greater than 175 psid/minute.

3.8.3 Test Results

Specimen Serial Number eight (8) had not burst when a pressure of 8,400 psig had been reached. All efforts to raise the pressure above 8,400 psig were ineffective, and, to conserve liquid Hydrogen, the test was aborted. The specimen was returned to ambient temperature and pressure, and removed from the cryostat.

3.0 DISCUSSION OF TESTS - continued

3.8 Burst Test - continued

3.8.3 (cont'd) The system was capped off, and the pressure checked (decay method) to 10,000 psig at ambient temperature. No leaks were found. The torque values (213 in/lbs) for the bolts holding the Aero-quip Marman Seal were checked, and were found to have "backed off" a matter of five (5) inch/pounds. Mr. C.Irvine (M.S.F.C.) was informed of the findings and, on his instructions, Serial Number nine (9) was installed in the test loop and an attempt made to burst it. This was also unsuccessful, although the pressure reached, this time, was 9,000 psig. Investigations at ambient pressure and temperature were conducted, and the diameters of the specimens Serial Numbers 8 and 9 were checked, against those recorded post Service Life, with very little' significant change noted. The possible conclusions to be drawn, from the inability to raise the pressure any higher, are that the seal is developing a leak at these higher pressures coupled with the strange thermodynamic properties of gaseous Helium at -412°F and 9,000 psig. This information was relayed to Mr. C. Irvine (M.S.F.C.) who instructed Ogden Technology Laboratories to burst both specimens at ambient temperature using gaseous Helium. Burst occurred at 5,500 psig on Serial Number eight (8) with a recorded specimen skin temperature of 105°F. Specimen Serial Number nine (9) burst at 5,400 psig with a recorded skin temperature of 105°F.

4.0 DESCRIPTION OF TEST EQUIPMENT

MARSHALL VIBRATION TEST

7-14-69

EQUIPMENT LIST

DESCRIPTION	MFG'R	MODEL NO.	SERIAL NO. OR ID NO.	RANGE	CALIBRATION LAST	DUE
ACCELEROMETER	ENDEVCO	2274	UA27	2.37 pC/g	3-20-69	9-20-69
"	"	2274	UA30	2.37 pC/g	3-20-69	9-20-69
"	"	2232C	LA65	7.05 pC/g	1-16-69	7-16-69
Q AMPLIFIER	U.D.	8PMCVA	2463	-	6-23-69	12-23-69
"	U.D.	8PMCVA	2464	-	6-23-69	12-23-69
"	U.D.	"	2462	-	6-23-69	12-23-69
EXCITER CONTROL	B&K	1019	2349	-	3-27-69	9-27-69
ELECTRONIC COUNTER	H/P	522B	221	-	11-18-68	8-18-69
OSCILLOSCOPE	H/P	122AR	2121	-	5-26-69	9-26-69
X-Y PLOTTER	MOSELEY	135	2123	-	5-22-69	11-22-69
TRUE RMS METER	LING	2416	2122	-	2-10-69	8-10-69
TRACKING FILTER	S.D.S.	SD 101A	~~427~~ 226	-	5-14-69	11-14-69
LOG CONVERTER	LING	LA100	2124	-	5-22-69	11-22-69
TAPE DECK	C.E.C.	2800	2522	-	4-5-69	10-5-69
ASDE 80 CONSOLE	LING	ASDE 80	2093-2112	-	N/A	
AMPLIFIER	LING	PP 120/150	53	-	N/A	
SHAKER HEAD	LING	A249	60	-	N/A	
TEMP RCDR	BARBER COLMAN	-	2189	-	4-7-69	10-7-69
D.C. PWR SUPPLY	H. LAB	812C	2023	0-40 V	N/A	
VISICORDER	C.E.C.	5-124	5776	-	5-16-69	11-16-69
Pressure gage	Ashcroft	~~2232~~	2232	0-10K Psig	5-5-69	8-5-69
Pressure gage	Ashcroft		2229	0-5K Psig	5-5-69	8-5-69
Control Oscillator	B&K.	1018	2130	5-5000 Hz	7-12-69	1-12-70
Electronic Counter	Hewlet Packard	522B	221		11-18-68	8-18-69
Vibration System	Ling	A249	Mach #464		Prior to	Use
Tracking Filter	Spectral Dynamics	SD-101A	427		7-11-69	7-11-70

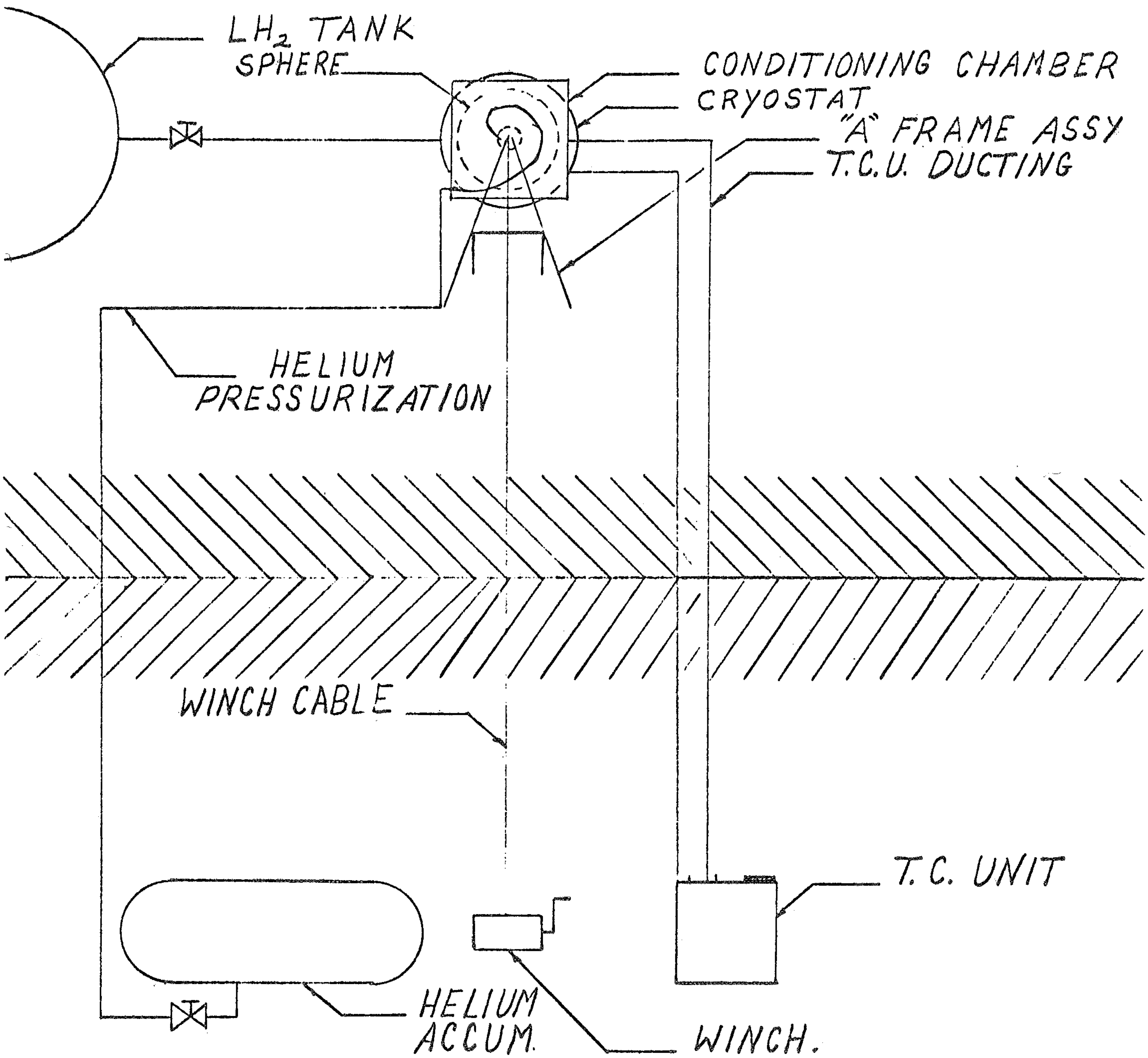
EQUIPMENT LIST

DESCRIPTION	MFG'R	MODEL NO.	SERIAL NO. OR ID NO.	RANGE	CALIBRATION LAST	DUE
PRESSURE GAGE	ASHCROFT	1082	2232	0,-10,000 PSIG	7-22-69	10-22-69
PRESSURE GAGE	ASHCROFT	1082	2232	0 - 10,000 PSIG	5-5-69	8-5-69
PRESSURE GAGE	ASHCROFT	—	2229	0 - 5,000 PSIG	5-5-69	8-5-69
PRESSURE GAGE	HELICOID	—	809	0 - 3000 PSIG	3-15-69	6-15-69
PRESSURE GAGE	ASHCROFT	—	634	0 - 100 PSIG	3-15-69	6-15-69
PRESSURE GAGE	ASHCROFT	—	673	0 - 15 PSIG	3-5-69	6-5-69
PRESSURE REGULATOR	TESCOM	-	26-1023-34	10,000 - 2,500	N.	A.
TEMP CONTROLLER	WEST	-	E 3619	-100 TO +800°F	N.	A.
POWER SUPPLY	HEWLETT Packard		E 2023	0 - 32 VOLTS 0 - 10 AMPS	N	A
COMPRESSOR	CARDAIR			0 - 10,000 PSIG	N	A
COMPRESSOR	CARDAIR			0-10,000 PSIG	N	A
RELIEF VALVE	AIRCO CRYOGENICS	—	PRV 203-8PP	4000 PSIG	N	A
REGULATOR	FISHER	-	630	100 PSIG INLET 3-10 OUTLET	N	A
REGULATOR	R.D.CO.	—	-	4,500 - 750 PSIG	N	A
Brown Pot	Honeywell	1117	1086	0-45 M.V.	4-30-68	4-30-69
Pressure Gage	Ashcroft	—	711	0-10000 Psig	3-15-69	6-15-69
Pressure Gage	Ashcroft	—	510	0-5000 Psig	3-15-69	6-15-69
Micrometer		—	172	18-24 inches	11-14-68	11-14-69
M.V. Brigde	Leeds & Northrup	—	2800	0-75 MV.	1-21-69	1-29-70

TEST SCHEMATICS

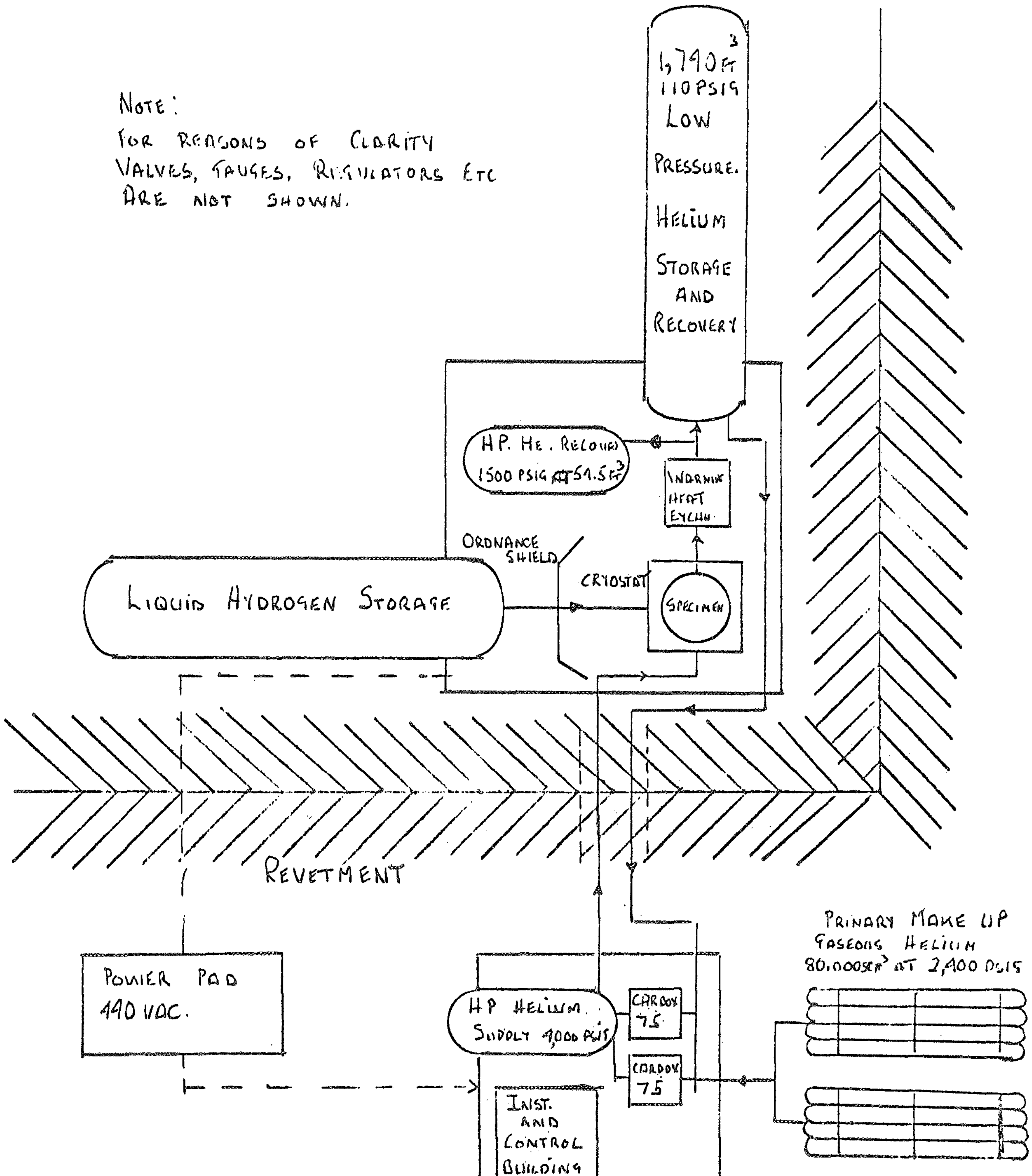
THERMALSHOCK TEST SETUP

FIG. I



9-18-69 WL

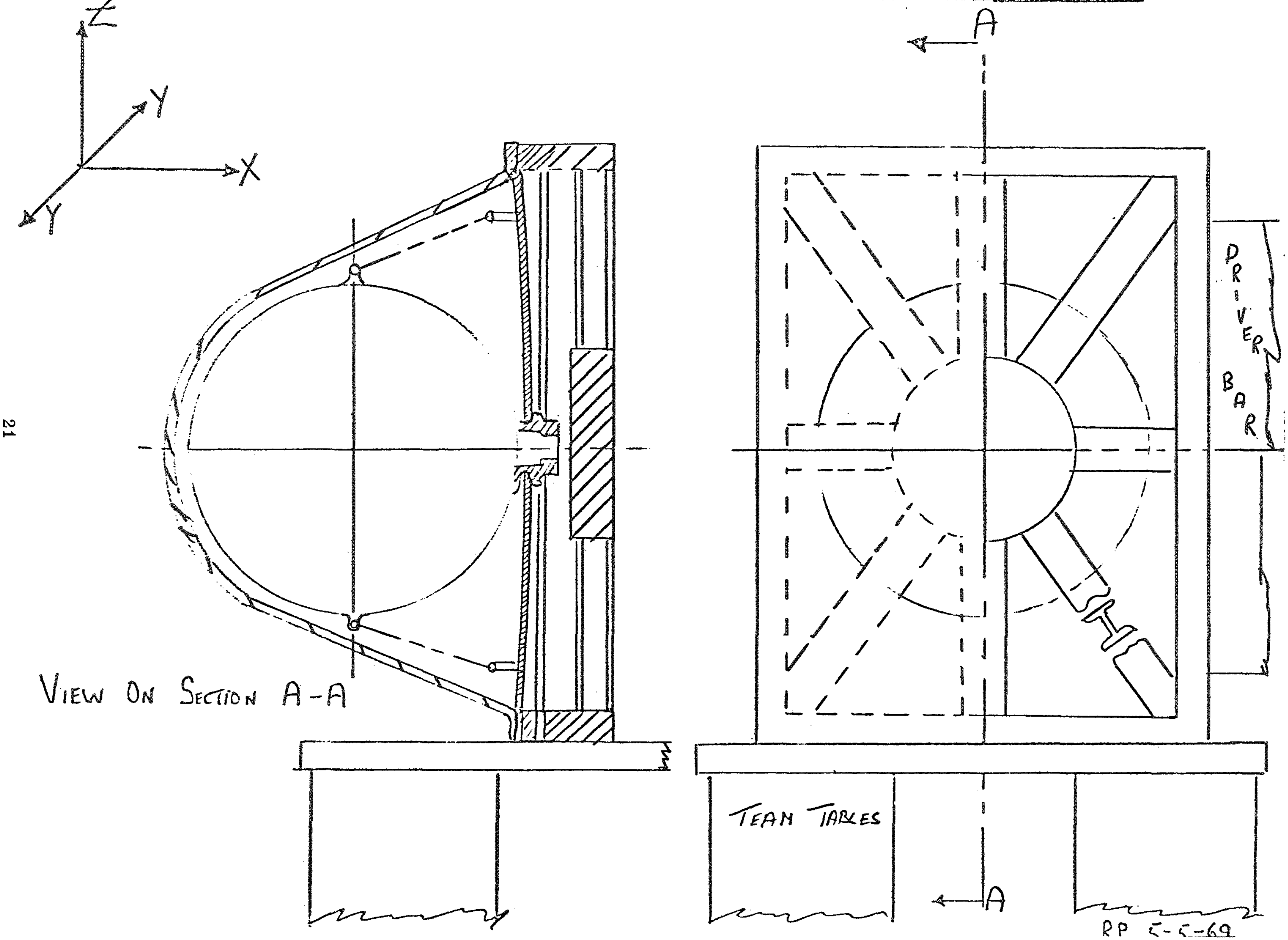
SERVICE LIFE TEST SCHEMATIC FIG II



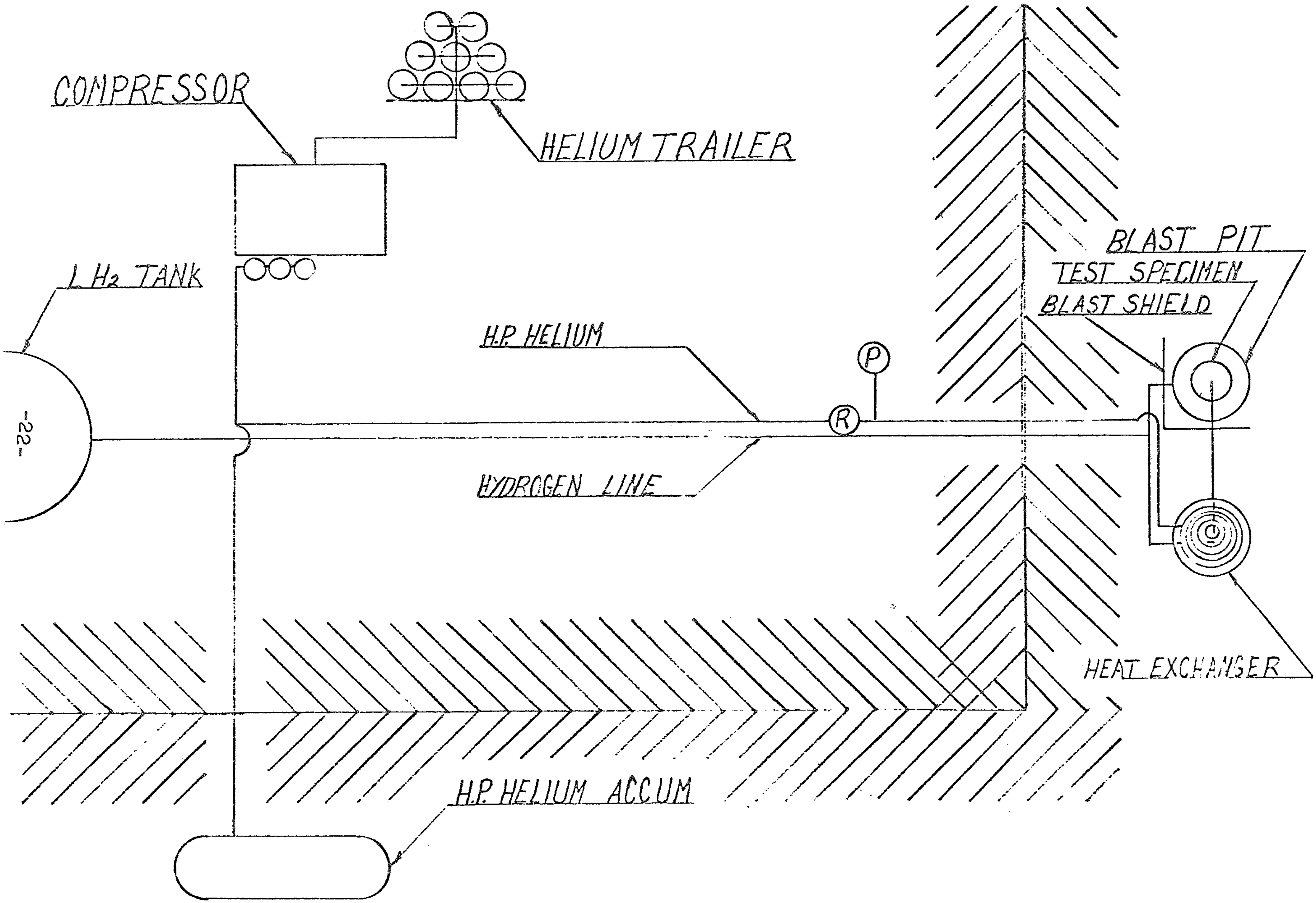
COMPRESSOR BATTERY AND CONTROL POINT.

R.P. 9-18-69

MARSHALL VIBRATION FIXTURE CONCEPT FIG III



BURST TEST SETUP FIG IV



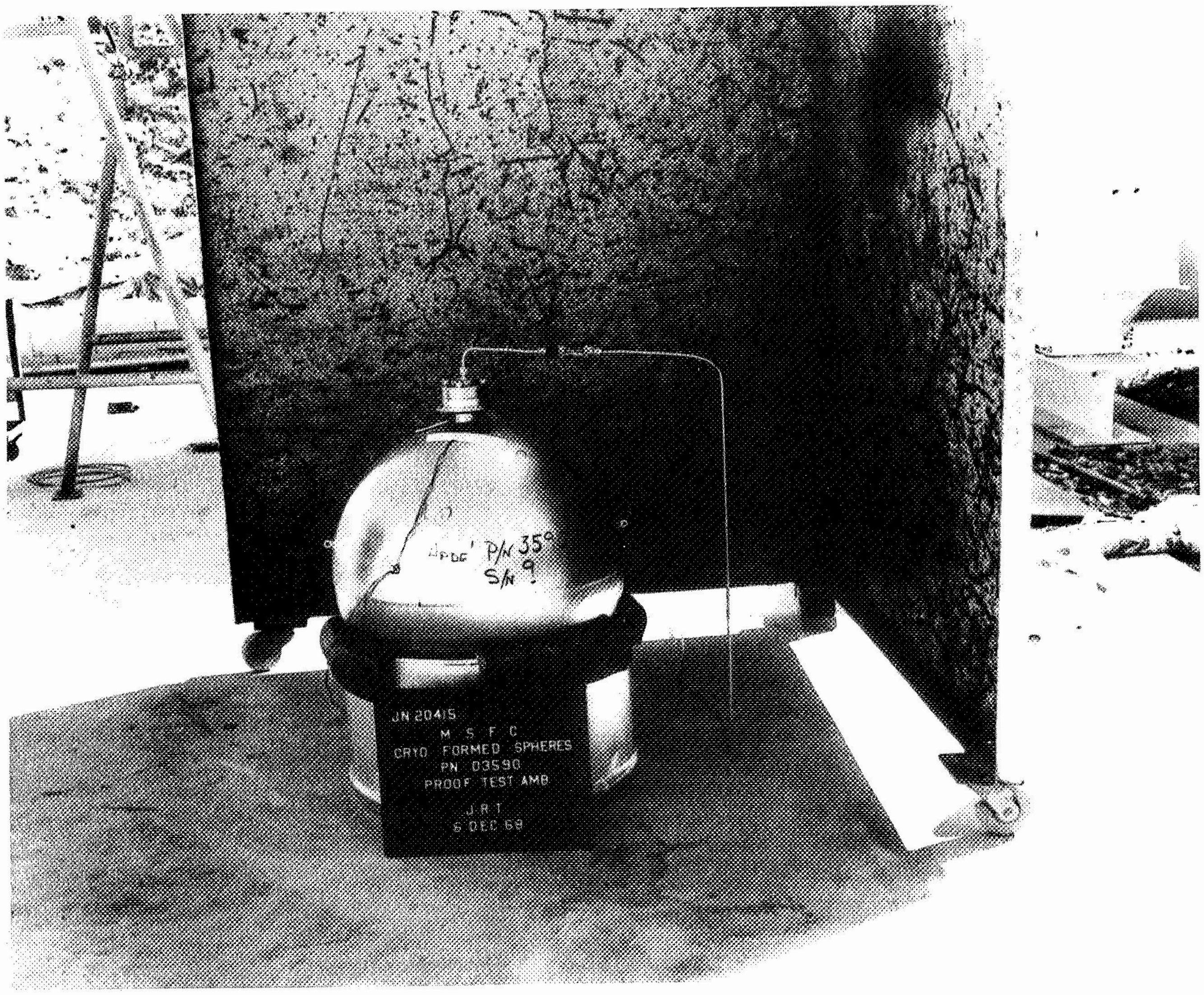
PHOTOGRAPHS

PHOTOGRAPH NO.1

RECEIVING INSPECTION

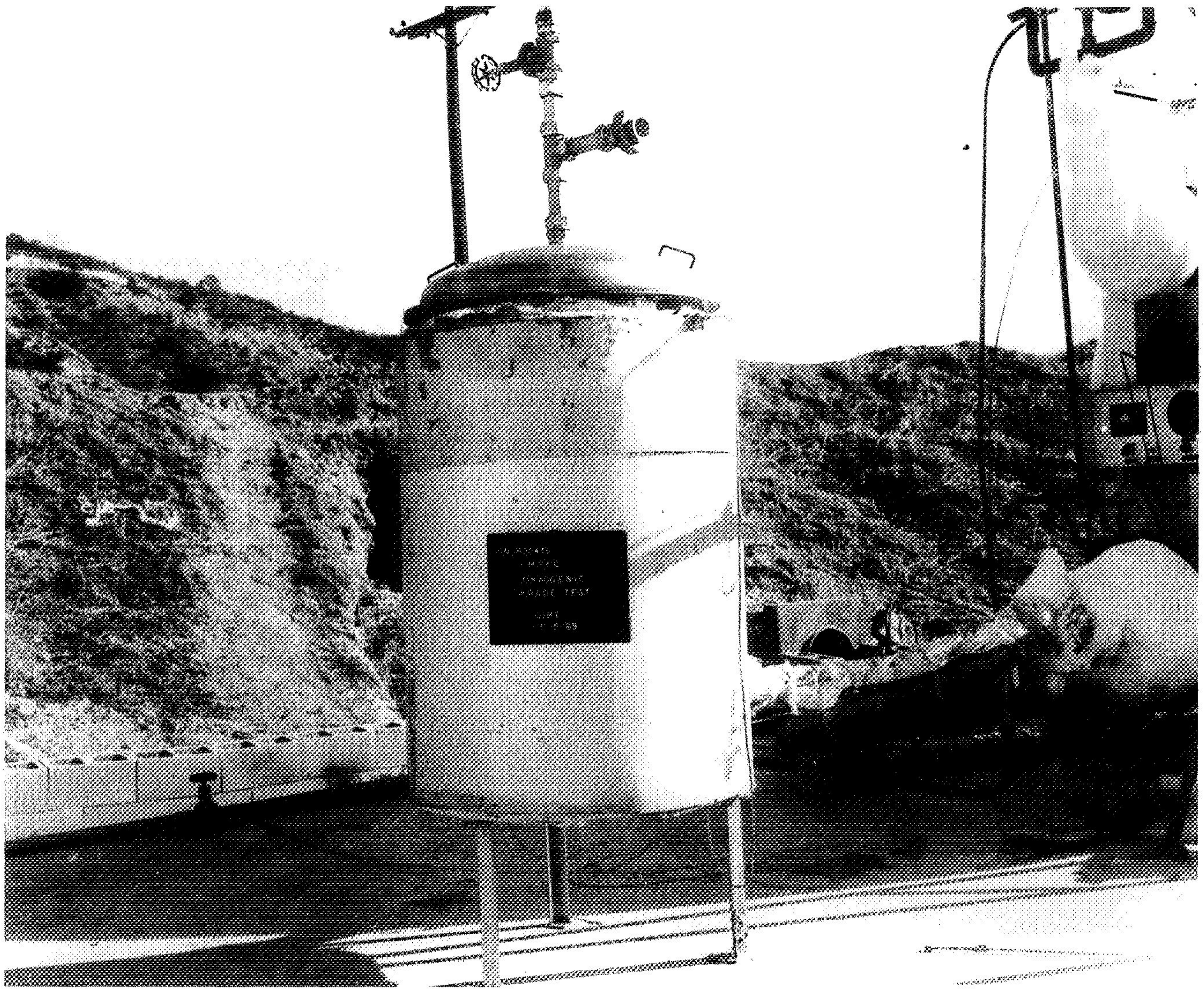
PHOTOGRAPH NO.1a

RECEIVING INSPECTION



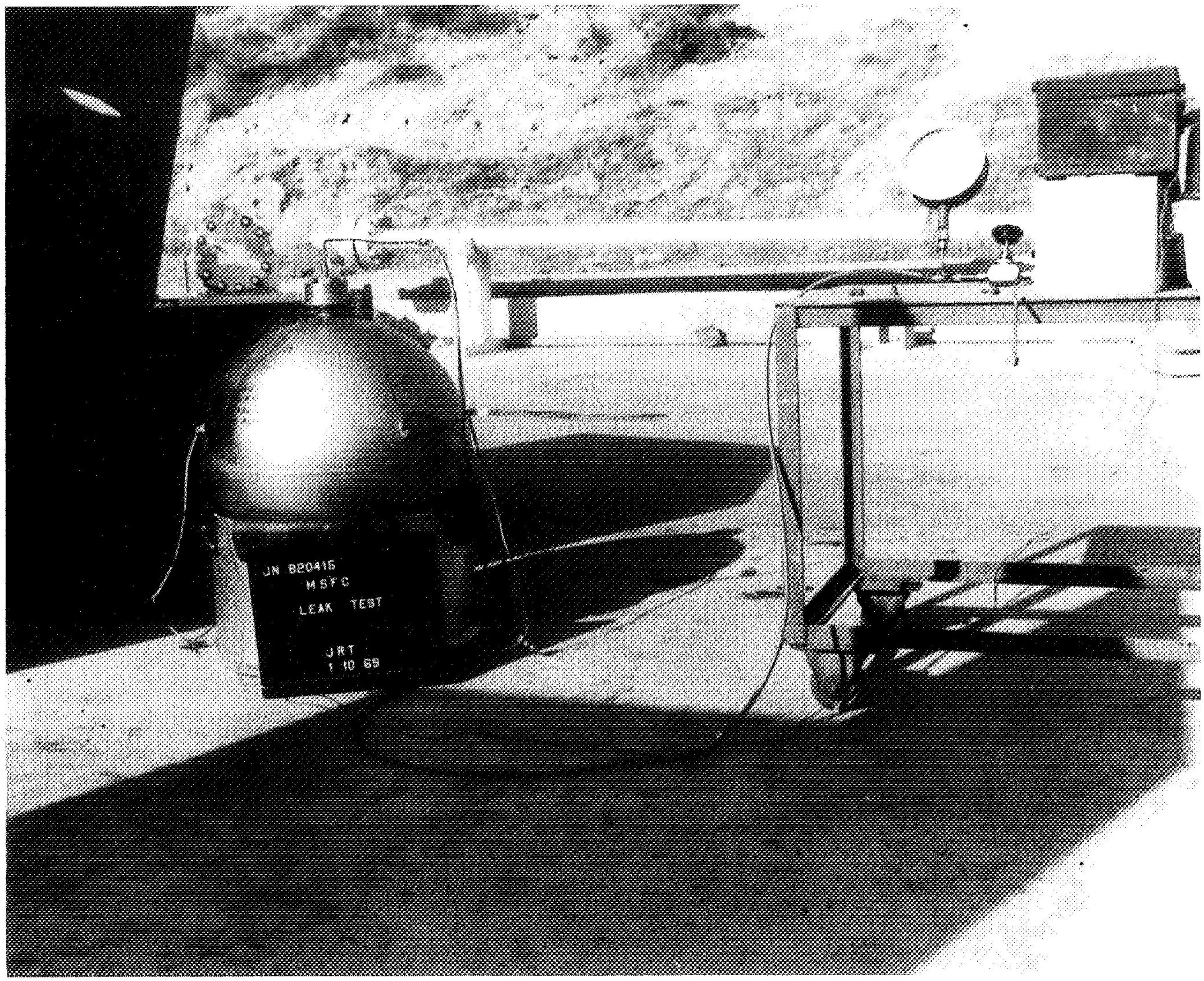
PHOTOGRAPH NO.2

PROOF TEST AMBIENT



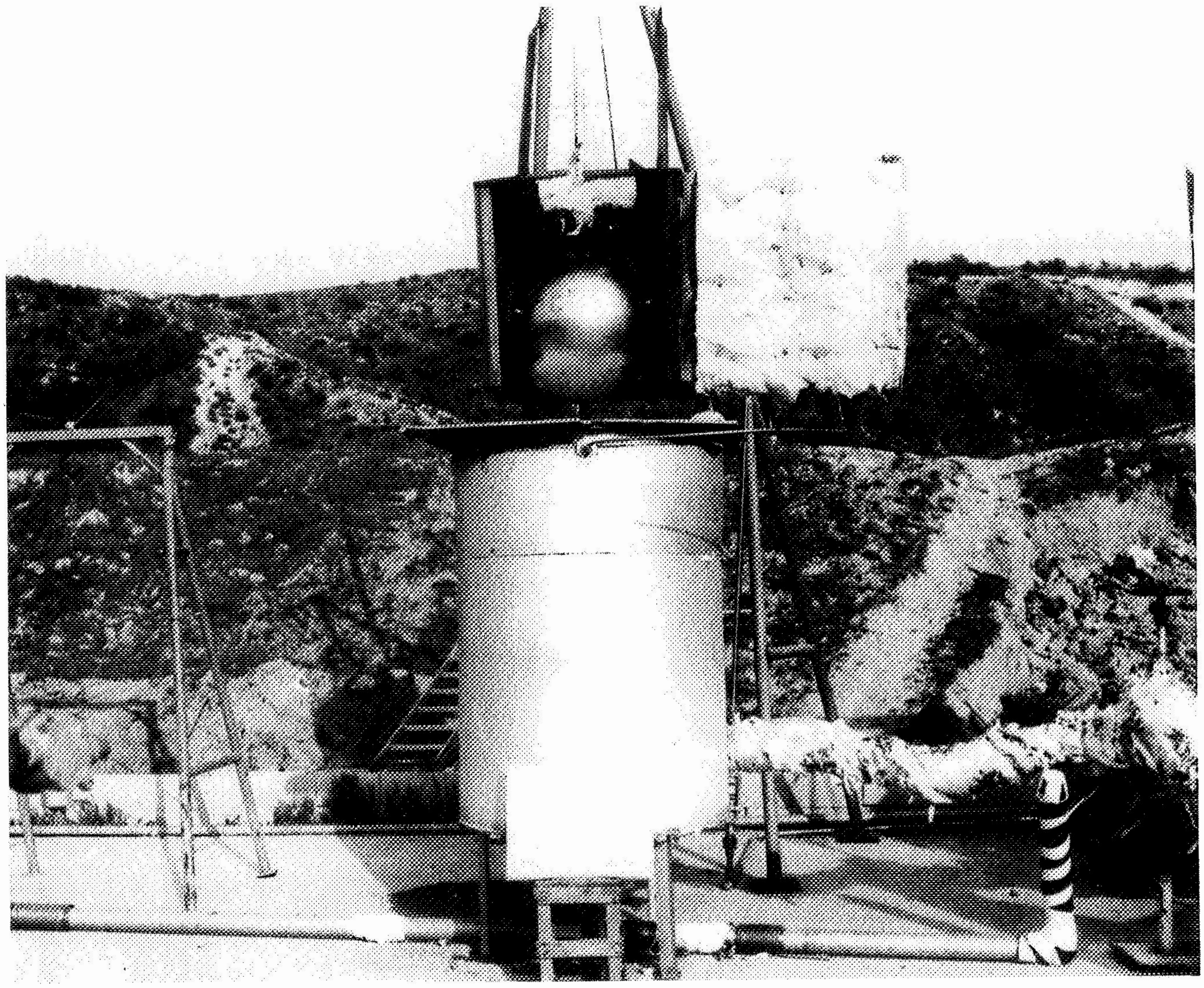
PHOTOGRAPH NO.3

PROOF TEST COLD



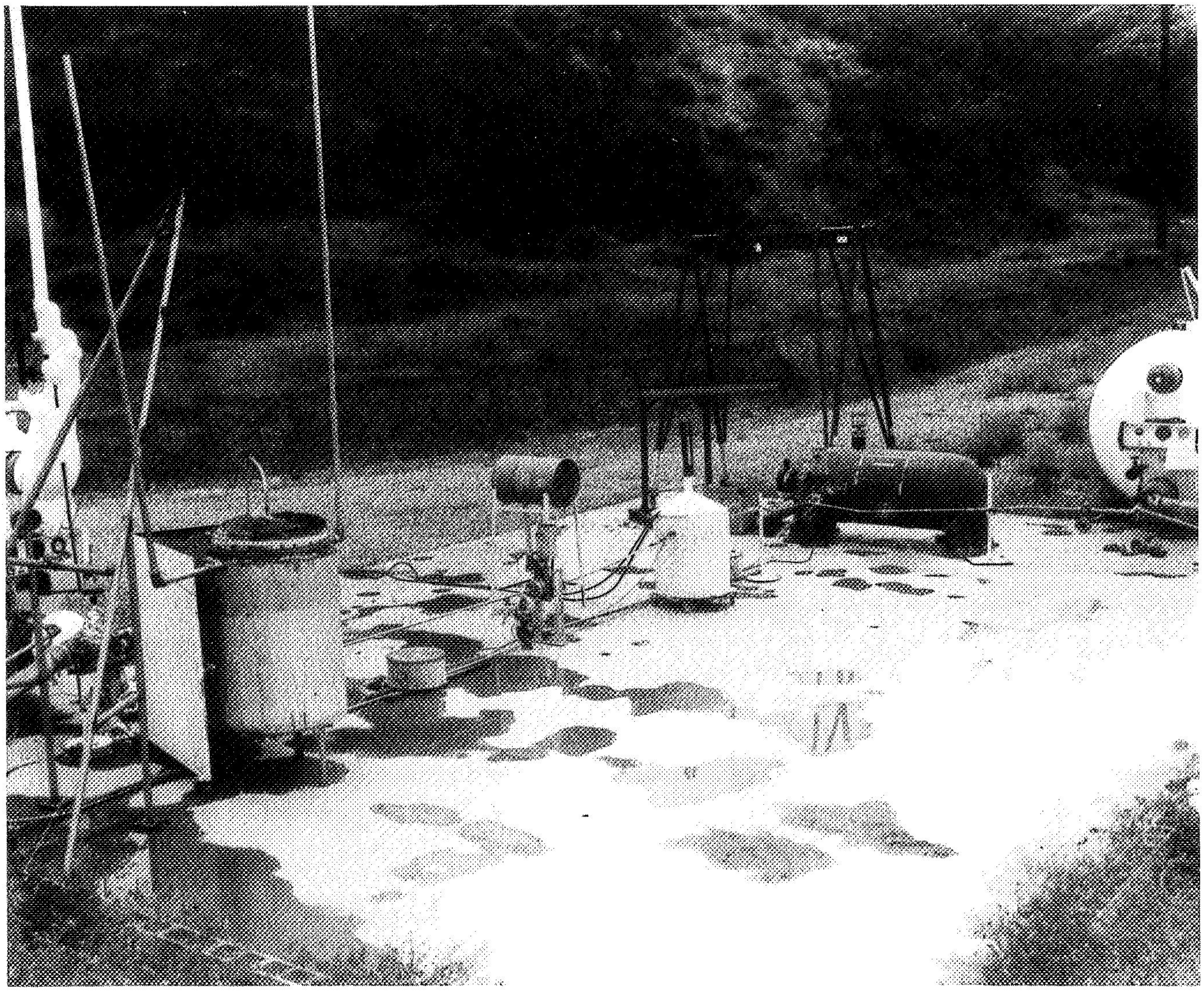
PHOTOGRAPH NO.4

LEAK TEST AMBIENT



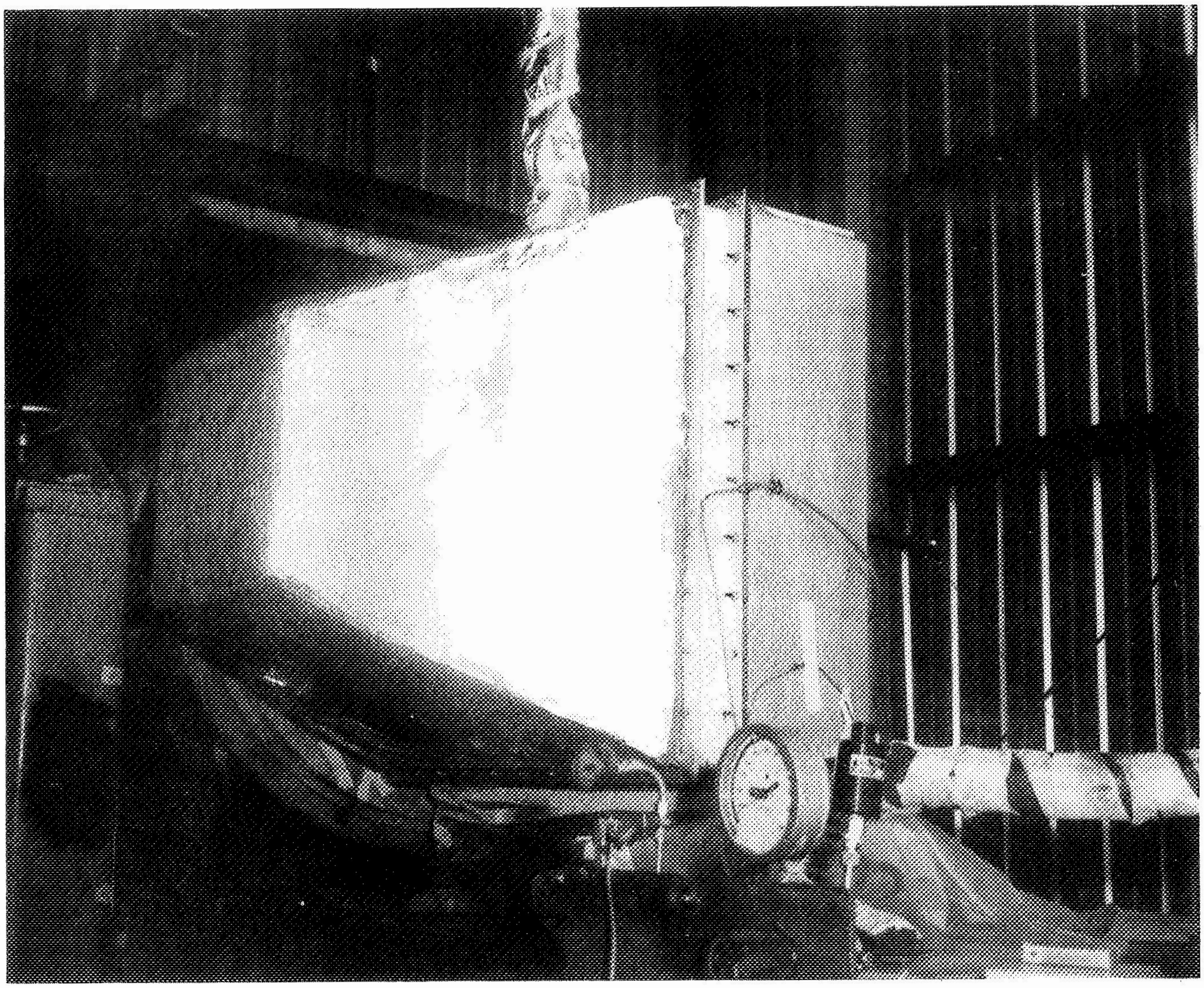
PHOTOGRAPH NO.5

THERMAL SHOCK TEST



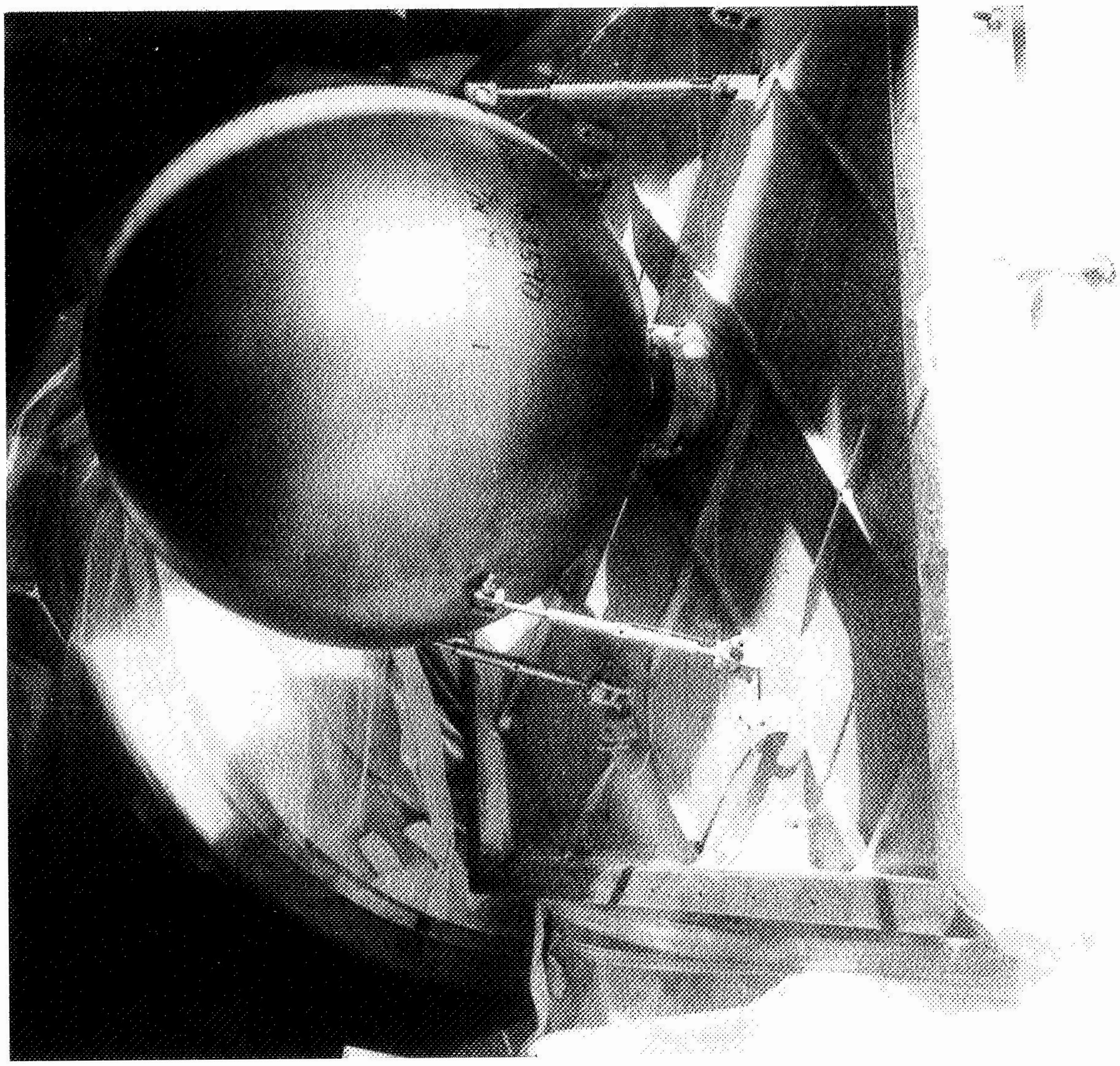
PHOTOGRAPH NO.6

SERVICE LIFE



PHOTOGRAPH NO.7

TYPICAL VIBRATION TEST SETUP



PHOTOGRAPH NO.8

VIBRATION TEST X-AXIS
Showing Borken Clevis